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ANALYSIS OF THE SEWAGE TREATMENT SYSTEM OF THE SILESIAN AGGLOMERATION

ANALIZA SYSTEMU OCZYSZCZANIA ŚCIEKÓW MIASTA AGLOMERACJI ŚLĄSKIEJ

Abstract: The construction of the technological treatment plant is closely related to the amount and physicochemical parameters of incoming sewage. The economic aspects and the principles of sustainable development also should be taken into account at the stage of sewage treatment plant construction planning. Moreover, in large cities, there is often greater number of sewage treatment plants, which should create an effective system for wastewater treatment. Municipal wastewater treatment system should not disturb the ecological balance of the area and cannot contribute to the deterioration of the living conditions of people (especially those living in the immediate vicinity of the sewage treatment plant). The paper compares the process lines of three wastewater treatment plants located in the city of Bytom: "Centralna" plant, "Miechowice" plant and "Bobrek" plant. The paper also compares the main indicators of the efficiency of the described wastewater treatment plants and the selected parameters of the sewage sludge. Based on the above data, an attempt was made to assess the proper operation of the sewage treatment system in the city of Bytom.

Keywords: wastewater treatment plant, efficiency of wastewater treatment technology

Introduction

The issue of sewage treatment is one of the most important problems of contemporary water and sewage management. According to the definition, a sewage treatment plant is a system of technical and biological facilities whose function is to remove and neutralise sewage.

The most common division of sewage treatment plants, in terms of the treatment methods used, is the distinction of mechanical, chemical, biological treatment plants and plants with increased biogene removal. In practice, these systems are operated in specific combinations, often concurrently, as complementary methods. This leads to the increase in the effectiveness of the sewage treatment process. Currently present technologies, such as A2/0 or UCT, allow for the reduction of the pollution load size in sewage. Basic pollutions present in sewage include: organic compounds and nutrients (nitrogen and phosphorus compounds) [1]. In the Polish law, the level of sewage pollution reduction is governed by the Regulation of the Minister of Environment on the conditions to be met when discharging sewage to water or to soil and on substances which pose a special hazard to aquatic environments [2].

Bytom is a city located in the southern Poland and belonging to the Silesian agglomeration. The area of the city is 6944 ha and population density amounts to 2516 inhabitants per km^2. The percentage of population using sewerage system in 2012 amounted to 90.1%, which places Bytom on the 32nd position among the cities with district rights in Poland [3].

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First references to the sewerage system network of the city date back to the 19th century; however, the construction of a developed sewerage system took place in the period 1900-1904. Along with the construction of the network, the construction of the city sewage treatment plant was also commenced. The plant was designed for the needs of 70,000 people. Treated sewage was discharged to the Bytomka River. With an increase in the city population, starting from 1933, the treatment plant was being modernised. In the subsequent years, there were 10 new smaller treatment plants established, frequently located within city districts.

At present, Bytom Municipal Company supervises the water and sewage management of the city of Bytom. The main investment of the recent years, supported with the EU funds, was the project "Improvement of the water and sewage management of the city of Bytom". Under the project, in the period 2004-2010, inter alia, the sewage treatment system was modernised. Instead of five treatment plants: "Centralna", "Miechowice", "Bobrek", "Rozbark" and "Stolarzowice", the first three are currently operated. They were subject to substantive extension and modernisation. In lieu of "Rozbark" treatment plant, the main sewage pumping station was created [4, 5].

The treatment plants existing in the city: "Centralna", "Miechowice" and "Bobrek", differ both in terms of their size and the sewage treatment technology used.

Further in the paper, process systems of three Bytom sewage treatment plants are presented and their effectiveness is analysed.

Sewage treatment technologies of the city of Bytom

"Centralna" sewage treatment plant is the largest treatment plant in Bytom. It is situated near the Szarlejka River. Its total area is about 11 ha, and the design flow rate is equal to 30 thousand m^3/d. There is also a laboratory at the premises of the treatment plant.

The process line is composed of a typical mechanical part (encapsulated grates; grit chamber; horizontal flow, radial primary sedimentation tank) and a biological part (three activated sludge chambers in the form of oxidation ditches with partly immersed aeration brushes) with increased treatment of nutrients (additional dephosphatation by adding PIX coagulant to oxidation ditches). Primary and excess sludge produced in the process is concentrated separately and then it is combined and subject to fermentation. There are 3500 m^3 of biogas generated in "Centralna" treatment plant daily. The obtained methane is first subject to desulphurisation, and then it is transferred to two power generators. The sludge remaining after fermentation is transported to filter presses and then it is sanitised with lime and exported outside the treatment plant.

Treated sewage is discharged to the Szarlejka River. The total time of sewage flow through the treatment plant amounts to about 24 h [6].

"Miechowice" sewage treatment plant is the second largest treatment plant in Bytom, occupying the area of about 6 ha, with sewage design flow rate of 12 thousand m^3/d. The total amount of sewage entering the treatment plan is derived from Miechowice district, and the average sewage flow rate is 3.5-8 thousand m^3/d.

Like "Centralna" treatment plant, it belongs to mechanical and biological treatment plants with increased treatment of nitrogen, phosphorus and carbon compounds. Downstream the classic mechanical part, biological reactors are used in the form of radial

Biomixes where denitrification and nitrification processes occur subsequently. Moreover, the dephosphatation process is supported by the addition of PIX coagulant upstream the reactors. A sedimentation chamber serves as the secondary settlement tank. The produced sludge is subject, in sequence, to aeration and dewatering, which leads to the form of sludge that can be used for agricultural purposes or for waste land reclamation. After treatment, sewage is transported to Row Miechowicki.

"Bobrek" treatment plant is the smallest and at the same time the oldest operating treatment plant in Bytom. The sewage entering that treatment plant comes from Bobrek - one of the smallest districts of Bytom; thus, the flow rate designed for that treatment plant has much smaller values in comparison to other treatment plants in Bytom - 800 m^3/d.

The process line is based on basic elements of the mechanical and biological treatment plant: a system of a sieve and grit chamber; Imhoff tank; three-chamber biological reactors. Settled sludge is transported to the sludge dewatering station, sanitised and then exported to the storage yard.

Treated sewage, as in case of "Miechowice" treatment plant, is discharged to Row Miechowicki [4].

Analysis of basic operating parameters of the treatment plant

Table 1 below presents requirements for efficiency in the reduction of selected pollutions in sewage acc. to [2].

Table 1

Minimum percentage of pollution reduction [2]

Indicator name	Minimum percentage of pollution reduction [%]		
	"Centralna"	"Miechowice"	"Bobrek"
COD	75	75	75
BOD_5	90	90	90
N_{total}	85	80	70-80
P_{total}	90	85	80
Total suspended solids	90	90	90

As part of the presented testing, two basic parameters were analysed determining the effectiveness of the treatment plant operation: COD and BOD_5. The analyses were conducted for the period January-June 2014. Data used for analyses purposes were obtained from "Centralna" and "Miechowice" treatment plants [4].

Table 2

COD and BOD_5 indicators of raw and treated sewage in "Centralna" and "Miechowice" treatment plants [4]

Month	"Centralna"				"Miechowice"			
	Raw sewage		Treated sewage		Raw sewage		Treated sewage	
	COD	BOD_5	COD	BOD_5	COD	BOD_5	COD	BOD_5
	[mg/dm^3]	[mg/dm^3]	[mg/dm^3]	[mg/dm^3]	[mg/dm^3]	[mg/dm^3]	[mg/dm^3]	[mg/dm^3]
January	1732	446	48.9	6	1137	627	61.7	16
February	1270	535	32	5	1062	351	19.1	4
March	822	275	49.1	7	2268	637	34.1	5
April	1100	323	57.5	6	1172	421	42.1	5
May	1019	453	71.3	13	670	308	19	2
June	1300	346	34.8	7	898	341	16.6	2

Figure 1 presents in a graphic form COD values for raw and treated sewage determined in the case of both analysed treatment plants.

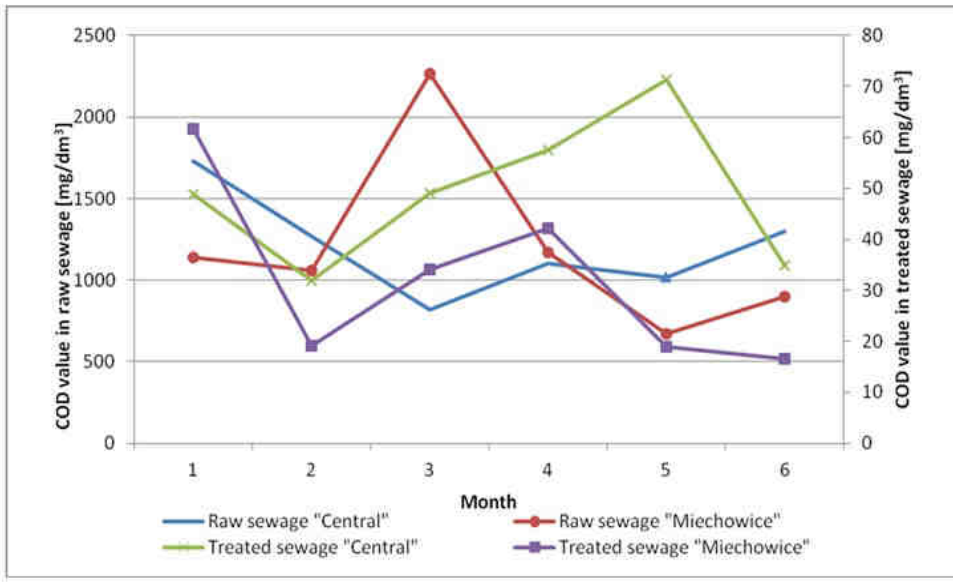

Fig. 1. COD values for raw and treated sewage determined in the case of both analysed treatment plants

The highest value of COD in raw sewage in "Centralna" treatment plant was recorded in January (1732 mg/dm^3), and the lowest one of 822 mg/dm^3 in March. The mean parameter value at inlet amounted to 1207 mg/dm^3. The maximum BOD_5 value occurred in February - 535 mg/dm^3 and the minimum one in March - 275 mg/ dm^3. The average amount of BOD_5 was 376 mg/ dm^3. While compiling analogically parameter values at outlet we obtain: the highest COD value in sewage in "Centralna" treatment plant in May (71.3 mg/dm^3), and the lowest one in February (32 mg/dm^3). The mean parameter value amounted to 48.9 mg/dm^3. The maximum BOD_5 value occurred in May - 13 mg/dm^3 and the minimum one in February - 5 mg/dm^3. The average amount of BOD_5 was 7.3 mg/ dm^3.

The above considerations demonstrate that in each of the months analysed, the indicator of reduction in COD and BOD_5 was higher than the one required in [2]. The mean value of COD reduction indicator amounted to 95.63% and of BOD_5 to 98.7%. Sewage parameters of "Miechowice" treatment plant were subject to a similar analysis. The highest value at inlet, amounting to 2268 mg/dm^3 was reached in March, and the lowest one, amounting to 670 mg/dm^3 - in May; the mean was 1201.2 mg/dm^3. The maximum BOD_5 value at inlet was 637 mg/dm^3 (March), and the minimum one - 308 mg/dm^3 (May). The mean value was 447.5 mg/dm^3. The maximum COD value at outlet was 61.7 mg/dm^3 (January), and the minimum one - 16.6 mg/dm^3 (June). The mean value was 32.1 mg/dm^3. The maximum BOD_5 value at outlet amounted to 16 mg/dm^3 (January) and the minimum one was 2 mg/dm^3 (May and June). The mean value was 5.67 mg/dm^3.

The above indicates that in each of the months analysed, the percentage reduction in COD and BOD_5 was higher than the one required under regulations [2]. The mean indicator value for COD amounted to 97.2% and for BOD_5 to 98.9% [4].

For other main indicators, "Centralna" and "Miechowice" treatment plants obtain reduction levels higher than those provided for in regulations.

Conclusions

The sewage treatment system of the city of Bytom is based on the functioning of three sewage treatment plants: "Centralna", "Miechowice" and "Bobrek", which are characterised by the following flow capacities, respectively: 30 thousand m^3/d, 5.5 thousand m^3/d, 800 m^3/d. Process lines of each treatment plant are based on the mechanical and biological part, and the two largest of these treatment plants are adapted to increased removal of nutrients.

In the analysed period (January-June 2014), "Centralna" and "Miechowice" treatment plants obtained the reduction level of main parameters characterising sewage that was higher than the standard one.

And the current management of sewage sludge from the sewage treatment plants of Bytom cannot rather be seen as a target solution. In the case of large city agglomerations, such as the city of Bytom, neutralisation of sewage sludge should not be based on agricultural use or on storage (unacceptable from 2016 onwards), but on thermal methods.

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ANALIZA SYSTEMU OCZYSZCZANIA ŚCIEKÓW MIASTA AGLOMERACJI ŚLĄSKIEJ

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Abstrakt: Budowa ciągu technologicznego oczyszczalni jest ściśle powiązana z ilością i parametrami fizykochemicznymi dopływających ścieków. Na etapie planowania należy rozważyć także kryteria zrównoważonego rozwoju oraz aspekty ekonomiczne. Ponadto, w dużych miastach na skuteczny system oczyszczania ścieków składa się często większa liczba oczyszczalni. Miejski system oczyszczania ścieków nie może zakłócać równowagi ekosystemowej danego obszaru ani przyczyniać się do pogorszenia warunków bytowania ludzi (szczególnie tych mieszkających w bezpośrednim sąsiedztwie oczyszczalni ścieków). W artykule porównano ciągi technologiczne trzech oczyszczalni ścieków znajdujących się na terenie miasta Bytom: Oczyszczalni „Centralna", Oczyszczalni „Miechowice" oraz Oczyszczalni „Bobrek". Zestawiono także główne wskaźniki efektywności oczyszczania oraz niektóre parametry osadu czynnego. Na podstawie powyższych danych podjęto próbę oceny prawidłowego funkcjonowania systemu oczyszczania ścieków w Bytomiu.

Słowa kluczowe: oczyszczalnia ścieków, skuteczność technologii oczyszczania ścieków